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PARACELSIUS AS A CHEMIST AND REFORMER OF CHEMISTRY.

PARACELSIUS (1493-1541) was in youth and early manhood a student of the chemical processes and theories prevalent in his time—particularly experienced in the operations of mining and metallurgy of the region in which his early life was spent. To this experience he evidently added by study of the principal authorities upon alchemical knowledge of the time—as references or allusions to them are to be found in his own writings.

The chemists of the period were of two classes—artisans employed in the mines or the working of metals, in pottery, glass, dyeing or similar industries, or mystics striving by obscure and occult means to transmute the baser metals into gold or silver, or to discover the elixir that should prolong life or endow its possessor with perennial youth.

The practical chemists or the artisans in chemical industry were in the early decades of book-printing not addicted to publishing. Their trade recipes and manuals doubtless were in use in the form of manuscripts for their own use but not usually issued for public information. The important pioneer authors in technical chemistry, Birin-guccio, George Agricola, Bernard Palissy, were also of the period of Paracelsus, though their works important to the history of chemical science did not appear until after the death of Paracelsus.

The principal chemical authorities extant during his life were the early Greek philosophers—of whom Pliny was the most important compiler, and the works written by or attributed to—for many were apocryphal—the Arabians Gheber and Avicenna, the Italian (?) Arnaldus de Villanova, the German Albertus Magnus, the Englishman Roger Bacon, and the Spaniard Raimundus Lullus (or Lully).

In so far as the chemical knowledge contained in these writers is concerned it appears from the studies of M. Berthelot, that they contained very little not known to Egyptian or Greek writers of the early centuries of our era. The metaphysical philosophy and mysticism of later Greek and Egyptian chemistry had however from Chaldean, Arabian and other Oriental sources been added to and elaborated to such a degree that the chemical writings of the above authors or those written under their names were fantastic, obscure, and often intentionally incomprehensible.

It is evident from the writings of Paracelsus that he was familiar with the chemical processes in use in the mines and metallurgical laboratories of the country in which he lived. His knowledge of the chemistry of his time was extensive and well assimilated. It is also evident that he was familiar with and influenced by the often fantastic speculative theories of Lullus, Arnaldus de Villanova and others respecting the nature of matter and the origins of metals.

Paracelsus wrote no treatises devoted exclusively to chemistry or alchemy. The few which appeared under his name and which answer such description, were forgeries—as judged both by internal evidence and by the evidence of Huser, who, while including them in his collection because they had been so published, characterized them as apocryphal.

Nevertheless in his other writings upon medicine, surgery, or natural philosophy, he includes much chemistry, particularly in the books entitled *De mineralibus*, *De natura rerum*, *Archidoxa*. In this unsystematically arranged and scattered material are recorded many facts not found in earlier writings, and operations more clearly described than previously. One historically important theory, that of the three elements (*tria prima*)—sulphur, mercury, and salt—as constituting principles of all other substances, seems to have been original with him, though using earlier speculations as material for its development.

Historians of chemistry have generally recognized the important influence of Paracelsus upon the development of chemical science in emphasizing its importance to medicine and pharmacology.

Strangely enough, however, it was just in relation to this, his most certain influence upon the development of natural science that his reputation for knowledge, originality, and indeed for honesty, was called in question for more than two centuries. The occasion for this was the appearance of some clever literary forgeries which appeared to place Paracelsus in the position of a plagiarist and to deprive him of his claim as the initiator of the era of chemical medicine. Huser's collection of the philosophical and medical works of Paracelsus, which included to be sure much of doubtful or spurious origin, appeared in 1589-1591.

About ten years later there began to appear a series of treatises by an alleged Benedictine monk—Basilius Valentinus. The publisher of these or at least of the earlier ones was a certain Johann Thölde. Thölde claimed to have discovered and translated into German the Latin manuscript. These works, especially the "Triumphal Chariot of Antimony," attracted immediate and wide-spread attention

because of their real chemical importance at the time. The work mentioned was a real contribution to the chemistry of antimony compounds. The inference from the text was that they were written early in the fifteenth century, therefore a century before Paracelsus.

As the appearance of this work occurred during the period of greatest popularity of the works of Paracelsus, it was soon noticed that there was a remarkable similarity both in matter and form of presentation between much contained in Basil Valentine and in Paracelsus. Like Paracelsus, Basil Valentine had abused the physicians and their authorities,—the mineral remedies practised by Paracelsus were here also advocated. Even the three primary principles, sulphur, mercury, salt, were found in Basil Valentine. The chemical facts were often more clearly described than in Paracelsus. In short, it was evident to critical minds that a plagiarism existed. To be sure, no previous writer had ever mentioned or quoted a Basil Valentine. Nor in fact were the alleged original manuscripts placed in evidence. Paracelsus, if he were the plagiarist, must then have had a monopoly in his access to the works of Basilius. There were indeed writers of the period who expressed disbelief in the authenticity of the find. Generally, however, these came to be accepted as genuine.

From certain passages in the writings it however became evident that they could not have been written as early in the fifteenth century as alleged by the supposed author, for allusions to metal used in type-founding, and to the French disease, made it evident that their date could not be earlier than the end of the fifteenth century. Nevertheless it became quite generally accepted that there had existed a writer who wrote under the name of Basilius Valentinus (though no record of such a name could be found in the register of Benedictines), that he lived before Para-

celsus, and that therefore Paracelsus had stolen his chemistry largely from the supposed monk. It may seem strange that such an hypothesis became so easily accepted, but it should be noted that at the time, a fierce warfare was in progress between the conservative medical profession and the university faculties on the one side, and the rapidly increasing revolutionary party of the Paracelsan school, on the other.

Paracelsus with the more influential and generally more scholarly classes was a name despised and hated. Plagiarism was to be expected from the leader and founder of the new school with its vagaries, fantasies, and charlatany. Against this presumption, the champions of Paracelsus fought at a disadvantage. Eventually also certain statements crept into literature which seemed to confirm the facts of the existence of the alleged Basilius, and so history finally accepted him as a writer previous to Paracelsus. The reinvestigation of this problem may be said to have commenced with the eminent historian of chemistry, H. Kopp, who, beginning by accepting the conventional hypothesis, after half a century's work in the early history of chemistry ended by stating that in his judgment the Basilius Valentinus literature was a forgery or forgeries of the beginning of the seventeenth century, and that in all probability Thölde the publisher was himself the author.¹

Since Kopp's time, other competent students have contributed to the solution of the problem,—Sudhoff, Ferguson, Lasswitz, and it may now be accepted as certain that no writings under the name of Basilius Valentinus had appeared nor existed either before or during the lifetime of Paracelsus nor indeed prior to the printing of his collected works. The works published and presumably written by

¹ Kopp, *Die Alchemie*, 1885.

Thölde therefore drew not only from Paracelsus, but doubtless also from Agricola and perhaps from still later writers.²

The works of two other alleged authors upon chemistry, Joh. and Isaac Hollandus, have also been shown to be post-Paracelsan and were literary forgeries of about the same period as the Basilius literature.

By the relegation of these writings to their true period, the relative importance of the chemical literature of Paracelsus is greatly enhanced. It is to him that we must turn for the initiative to medical chemistry as well as for its propaganda; to him also the credit is due for the first announcement of many interesting though by no means epoch-making chemical facts. Through this revision of history also Paracelsus is freed from the odium of plagiarism and consequent lack of originality which in the minds of the majority of medical or chemical students has so long attached to him.

The interest of Paracelsus in chemistry was on the whole practical, though his adopted philosophy and the need he felt to replace the Galenic and Aristotelian theories by new ones leads him often into theorizing. And to some extent these theories doubtless influenced his practice. Thus in the preparation and purification of his *arcana* or simple extracts or principles of plants and minerals, he seems to have been guided, as a working hypothesis, by his neo-Platonic concept of the spiritual sympathetic relations of all things in the universe toward man and his health. Thus if he could free the real active spirit or principle of the plant from grosser admixtures it should be more efficacious. So he rejected the extremely complex decoctions of herbs of the customary pharmacopœia for his simpler *arcana*.

² For a more detailed account of the Basil Valentine forgery cf. Stillman, *Popular Science Monthly*, December, 1912, "Basil Valentine."

It is by no means necessary to assume that all these new remedies he introduced were originated by him. Many of them were, though not authorized by the faculties, in use as popular remedies in certain localities at least, or used by irregular practitioners. Thus mercury preparations mixed with fats had been introduced for external use in certain treatments by Italian physicians previous to Paracelsus. It is nevertheless true that in the extension of the pharmacopœia to a great number of preparations requiring the operations and methods of chemistry for their preparation he exerted his greatest influence upon chemical activity and development. Not only mercury and antimony preparations but preparations of lead, arsenic, copper, and iron entered into his remedies. Opium also seems to have entered into his practice quite largely and the word laudanum seems to have originated with him—whether or no his “laudanum” was an opium preparation, as on that point the doctors disagree.

The name of zinc first appears in the writings of Paracelsus, though that he therefore first named it, is not to be inferred. It was probably at least locally in use in mining regions in which he had studied.

“For that is a metal which fire may subdue and which can be made into an instrument by man. Such namely are gold, silver, iron, copper, lead, tin. For these are generally known as metals. Now there are some metals which are not recognized in the writings of the ancient philosophers nor commonly recognized as such and yet are metals; as *Zincken* (zinc), *Kobaltet* (?), which may be hammered and forged in the fire.”⁸

“There is also another metal called *Zincken*. . . . This is not generally known, it is in this sense a metal of a special kind and from another seed (i. e., origin). Yet

⁸ Paracelsus, *Op. fol.* (Strassburg, 1616-18), II, 134, “De mineralibus.”

many metals adulterate (alloy) with it. This metal is itself fusible for it is from three fusible elements (i. e., the three primary elements), but it has no malleability but only fusibility. And its color is different from the colors of others, so that it is not like the other metals as they grow. And it is such a metal that its *ultima materia* is not as yet known to me. For it is nearly as strange in its properties as quicksilver. It admits of no admixture and does not endure metallic manufacture, but stands by itself.”⁴

Mercury (quicksilver), Paracelsus did not consider a true metal. Though of “metallic nature,” it could not be hammered or cast, lacked malleability, but it is of metallic nature because “by chemical art it can be brought to malleability and fashioning” (doubtless meaning in its alloys or amalgams).

The first mention of bismuth is sometimes, though incorrectly, ascribed to Paracelsus, as it is mentioned by Agricola in his *Bermannus*, printed in 1530, and even by a still earlier anonymous writer.⁵

Another observation credited to Paracelsus is the distinction between “alums” and “vitriols” in ascribing to the former an earth as base, and to the latter a metal. This was for that time a logical discrimination, for it was Sir Humphrey Davy who first demonstrated that the so-called “earths” could be reduced to metals hitherto unknown. The term “reduction” (*reduciren*) as applied to the obtaining of metals from their ores is also said to have been first introduced into chemical literature by Paracelsus.

Many other processes not new are described by Paracelsus, and his descriptions are frequently straightforward and with none of the intentional mystification of the great bulk of alchemical writings of the time or of many even

⁴ *Loc. cit.*, p. 137.

⁵ Cf. Agricola, *De re metallica*, edited by Hoover, p. 433, footnote.

in the century following. That they are not always intelligible is true, but this is rather from the use of terms whose meaning is not now clear, or from careless and hasty writing or editing. The following is an illustration of his better style. It describes the preparation of white lead and vinegar and carbon dioxide gas.

"The mortification (from *mors*, death) of lead consists in converting it into *cerussa* which is also called white-lead (*Bleiweiss*). Its preparation is in two ways, one in medicine, the other in alchemy. Its preparation in medicine is thus—that you hang it (the lead) in thin sheets over a sharp wine-vinegar in a glazed pot. The pot is then well stoppered so that no spirits may volatilize and set in warm ashes, or in winter behind the stove: then you will find in ten to fourteen days good white lead adhering to the sheets, which you may remove with a hare's foot, and again hang the sheets, and do this until you have white-lead enough. The other preparation of white-lead—in alchemy—is like this except that in the vinegar much of the best and finest salmiac is dissolved. That gives a fine and subtle white-lead."⁶

By the first of the two methods mentioned the necessary carbon dioxide gas for the formation of the carbonate must come from the fermentation of the vinegar. This makes a slow process to be sure. In the second process, with the addition of the salmiac, the sal ammoniac as then prepared often consisted of or contained ammonium carbonate which with the acetic acid of the vinegar liberated carbon dioxide in greater quantity than from the fermentation of the vinegar alone. Similar descriptions of this process exist in ancient Greek and Roman writers, though without use of sal ammoniac.

With respect to his theoretical views of chemistry, we

⁶ *Op. fol.*, I, 893-4, "De natura rerum."

should naturally expect to find them fanciful and unscientific, and we are not disappointed. They are based upon the theories of his predecessors with such changes as commend themselves to his own preconceptions. Thus he does not deny the possibility of transmutation of the metals. But his practical sense rejects the search for it as a waste of valuable energy otherwise more profitably employed.

"Many have said of alchemy that it is for making gold and silver. But here such is not the aim but to consider only what virtue and power may lie in medicines."⁷

"Not as they say—alchemy is to make gold, make silver: here the purpose is to make arcana and to direct them against diseases."⁸

From the point of view of the history of development of ideas in physical or chemical science it is interesting to find that our word *gas* which was first formulated by Van Helmont as a generalization to include the various elastic fluids which we now call by that name, finds its suggestion in Paracelsus.⁹ Though suggested by Van Helmont the term *gas* was slow in making its way. It will be remembered that the celebrated work of Jos. Priestley in the eighteenth century bore the title of *Different Kinds of Air*. Van Helmont (1577-1644) who was strongly influenced by Paracelsus and one of his strong defenders, though differing from him in his views in many respects, tells us that he derives the word *gas* from the Greek *chaos*.¹⁰ This term, however, is used repeatedly by Paracelsus as a generalized term for air, and certainly was familiar to so thorough a student of Paracelsus as Van Helmont manifestly was.

Thus Paracelsus says, "And they are born from the elements..... as for instance out of the element *terrae*

⁷ *Op. fol.*, I, 149, "Fragmenta medica."

⁸ *Op. fol.*, I, 220, "Paragranum."

⁹ See Strunz, *J. B. van Helmont* (1907), p. 30, and E. O. von Lippmann, *Chemiker-Zeitung*, XXXIV, p. 1.

¹⁰ J. B. van Helmont, *Opera Omnia*, 1682, II, 132.

(earth) its species, and out of the element *aquae* (water) its species, out of the element *ignis* (fire) its species, out of the element *chaos* its species.”¹¹

“Thus all superfluous waters run into their element called the sea (*mare*) ; whatever is terrestrial (earthy) returns to its element called earth (*terrae*) ; what is igneous into the element fire (*ignis*) ; and what is aerial (*aereum*) that runs into its element *chaos*.¹²”

“The elements in man remain indestructible. As they have come to him so they come from him. What he has received from the earth goes back to the earth and remains such so long as heaven and earth stand; what he has in him that is water that becomes water again, and no one can prevent it; his *chaos* goes again into the air (*Luft*), his fire to the heat of the sun.”¹³

Thus “chaos” used by Paracelsus for air became “gas” to his disciple Van Helmont, though even in Van Helmont’s time the real differences between gases were so little understood that the value of the generalized term was not appreciated at the time. It required another century of accumulated facts to make it necessary.

It would be interesting to know if Paracelsus really discriminated between air and the vapor of water, or other gases. The following passage is not conclusive, being capable of different interpretations. It is nevertheless of interest.

“When, from the element water, air (*Luft*) is to be separated, that takes place by boiling, and so soon as it boils, the air separates from the water and takes with it the lightest substance of the water, and in so much as the

¹¹ *Op. fol.*, I, 269, “Labyrinthus medicorum.”

¹² *Op. fol.*, I, 291, “Das Buch von den tartarischen Krankheiten.”

¹³ *Chir. Bücher*, fol. 378, “Von offenen Schaden.”

water is diminished so according to its proportion and quantity is the air also diminished."¹⁴

So strong an adherent as Paracelsus of the neo-Platonic notions of the interrelation of all things in the universe, would naturally be interested in the prevalent theories of the nature of matter and of its changes. That the causes which influence health and disease might be understood it was necessary that the nature of chemical changes, and the constitution of matter should be understood.

Hindu, Greek, Arab, and later philosophers had speculated upon the nature of matter with the result of the final crystallization in medieval philosophy of the theory of the four elements, fire, air, earth, and water. Upon this was founded the Galenic doctrine of the four humors in the human organism, and the theory had become in the medieval Aristotelianism petrified into infallible dogma.

Medieval alchemists had as the result of the study of metallurgical chemistry, of observations upon the occurrence of the metals in the earth and the changes to which they are subject, from time to time developed certain independent notions of the nature of matter. The strange properties of mercury and of its alloys with other metals, the occurrence of sulphur in many ores and its appearance or disappearance in the treatment of these ores, had given rise to speculations as to the possible relations of these substances to the growth or development of the metals in the earth. From such phenomena and from the peculiar properties of many alloys of the common metals arose doubtless the hopes of transmutation of base metals into purer or more precious metals.

Raimundus Lullus and other early alchemists had assumed therefore that mercury and sulphur were present in all metals. In the literature of the Middle Ages or early

¹⁴ *Op. fol.*, I, 791, "Archidoxa."

Renaissance the mercury or mercuries, and the sulphur or sulphurs were not the elements sulphur and mercury as we understand them but were supposed to be substances related to these elements and capable of influencing the colors, fusibility, behavior toward fire etc., of the metals of which they were constituent principles. There was no agreement among writers of the time however, as to the properties of these elementary substances, nor as to their role or function in the metals or their ores.

Upon this vague and variable foundation, this inheritance from the alchemists, Paracelsus constructed his more comprehensive and consistent theory of the three elements, sulphur, mercury, and salt, which was destined to become the most influential theory of the constitution of matter until gradually replaced by the phlogiston theory in the eighteenth century.

Paracelsus recognized the four Aristotelian elements or principles—earth, air, water, fire—but considered them also as consisting of the three primary elements (*tria prima*). To his three elements he assigned more definite and better characterized functions than had previously been recognized. Sulphur was the combustible principle in all substances, not merely in the metals; mercury that which imparted the property of liquidity, or fusibility, and volatility; and salt that which determined the non-volatility and incombustibility of substances.

"For all that fumes and disappears in vapors is mercury; all that burns and is consumed is sulphur; all that is ashes is also salt."¹⁵

These three constituents of all matter are not, however, to be understood as answering to the definition of elementary substances as at present accepted. Like the Aristotelian elements they also typified qualities or principles. Thus

¹⁵ *Op. fol.*, I, 898.

sulphur was not a substance of constant and invariable properties entering into the constitution of other substances, but varied with the substance which contained it. To use the words of Paracelsus—"For as many as there are kinds of fruits—so many kinds are there of sulphur, salt, and so many of mercury. A different sulphur in gold, another in silver, another in iron, another in lead, zinc, etc. Also a different one in sapphire, another in the emerald, another in ruby, chrysolites, amethysts, magnets, etc. Also another in stones, flint, salts, spring-waters (*fontibus*), etc. And not only so many kinds of sulphur but also so many kinds of salt,—different ones in metals, gems, etc.... And the same with mercuries, different ones in the metals, others in gems, and as many as there are species—so many mercuries. And yet they are only three things. Of one nature is sulphur, of one nature salt, of one nature mercury. And further they are still more divided, so that there is not only one kind of gold but many kinds of gold,—just as there is not only one kind of pear or apple but many kinds. Therefore there are just as many different kinds of sulphurs of gold, salts of gold, mercuries of gold."¹⁶

We should therefore consider the three elementary principles of Paracelsus and his followers rather as generalizations of certain properties inherent in and common to matter, than as elements in the modern sense. The importance that this theory possessed for his time, was that it was more closely related to phenomena observed in chemical experimentation than the concept of the Aristotelian elements. Consequently it became the dominant hypothesis as to the nature of matter until in the seventeenth century the keen critical analysis of Robert Boyle laid bare its inadequacy and unscientific basis. Boyle indeed it was who

¹⁶ *Op. fol.*, II, 132, "De mineralibus."

first clearly enunciated the modern definition of an element as a substance which cannot by our efforts be resolved into simpler constituents, though he did not venture to apply this definition to any particular substance.

The great service of Paracelsus to chemistry was not in any epoch-making discovery nor in any development of theory of permanent value, but in opening a new and great field for chemical activity in the application of chemistry to the preparation of mineral and vegetable remedies. He not only put into use many known chemical substances in his practice, but he advocated insistently and forcefully the necessity of the knowledge of chemistry to the physician, and emphasized the value of experiment as against dependency upon the records of the ancients.

"But because you are ignorant of alchemy you are also ignorant of the mysteries of nature. Do you think that because you have Avicenna and Savonarola, Valescus, and Vigo that you therefore know everything? That is but a beginning.... That which Pliny, Dioscorides, etc. have written of herbs they have not tested, they have learned it from noble persons who knew much about their virtues and then with their smooth chatter have made books about it.... Test it and it is true. But you do not know it is true,—you cannot carry it out, you cannot put to proof your author's writings. You who boast yourselves *Dotores* are but beginners.

"What do Hermes and Archelaus attribute to vitriol? —Great virtue,—and it is true such virtue is in it. But you do not know wherein it lies, neither in the green nor in the blue vitriol, and yet you call yourselves masters of natural things and do not know that! You have read so that you know what is there written but you can make no use of it.

"What do other chemists and philosophers say about

the powers of mercury? Much indeed and it is true. But you do not know how to prove it true.... You do nothing but read, 'that is in this, this is in that, that is black and this is green—and further than that I can (God help me) do nothing, thus I find it written.' Do you think I have laid my foundation (of medicine) without reason in the arts of alchemy? Tell me who are to be trusted in the knowledge of the virtues of things in nature, those who have written and not known how to make proof, or those who have the knowledge to make proof—but have not written? Is it not true that Pliny has never shown any proofs? What did he write then?—That which he had learned from the alchemists. And so you if you do not know and recognize who these are—you are but a lame physician."¹⁷

Another illustration of his argument for the value of experiment and his criticism of those who depended solely upon the ancient authorities is the following (he is discussing the preparation of medicinal principles):

"The separation of those things that grow from the earth, and are easily combustible, as all fruits, herbs, flowers, leaves, grass, roots, woods, etc., takes place in many ways. Thus by distillation is separated from them first the phlegm (i. e., a watery distillate); then the mercury (i. e., volatile or gaseous products) and the oily portion; third its resin; fourth its sulphur (that which burns); and fifth its salt (non-volatile and uncombustible, or the ash). When this separation has taken place by chemical art, there are found many splendid and powerful remedies for internal and external use.

"But because the laziness of the supposed physicians has so obtained the upper hand and their art serves only for display, I am not surprised that such preparations are

¹⁷ *Op. fol.*, I, 221-2, "Paragranum."

quite ignored and that charcoal (i. e., fuel) remains cheap. As to this I will say that if the smith could work his metals without the use of fire, as these so-called physicians prepare their medicines without fire, there would be danger indeed that the charcoal-burners would all be ruined and compelled to flee.

"But I praise the spagyric (chemical) physicians, for they do not consort with loafers or go about gorgeous in satins, silks and velvets, gold rings on their fingers, silver daggers hanging at their sides, and white gloves on their hands, but they tend their work at the fire patiently day and night. They do not go promenading, but seek their recreation in the laboratory, wear plain leathern dress and aprons of hide upon which to wipe their hands, thrust their fingers among the coals, into dirt and rubbish and not into golden rings. They are sooty and dirty like the smiths and charcoal-burners, and hence make little show, make not many words and gossip with their patients, do not highly praise their own remedies, for they well know that the work must praise the master, not the master his work. They well know that words and chatter do not help the sick nor cure them. Therefore they let such things alone and busy themselves with working with their fires and learning the steps of alchemy. These are distillation, solution, putrefaction, extraction, calcination, reverberation, sublimation, fixation, separation, reduction, coagulation, tincion, etc."¹⁸ The type of chemical physician here alluded to existed among the surgeons of Strassburg, exemplified in Brunschwyg's *Liber Destillandi* (1500).¹⁹

This opening up of a new field of chemical activity which promised so much of importance in its development and which touched directly upon the field of the practice of

¹⁸ *Op. fol.*, I, 906, "De natura rerum."

¹⁹ See article by the present writer in *The Scientific Monthly*, February, 1918, p. 167.

medicine, the most important field of natural science at that period, and the appeals of Paracelsus to abandon the search for the transmutation of metals and other vain goals of the alchemists, met almost immediate response among those students who were interested in the study of nature—and there were many such—and it was indeed from the chemists that the most enthusiastic and productive followers of Paracelsus arose. A new and important impulse had been imparted to chemistry, so that in spite of the fact that no great chemical discoveries or generalizations can be attributed to Paracelsus he may yet with justice be called a reformer of chemistry.

It is interesting to contrast the work of Paracelsus with that of his great German contemporary, Georgius Agricola (Georg Bauer), 1494-1555. Agricola was also medically trained as well as being thoroughly versed in mining and metallurgy.

His descriptions of mining and of metallurgical and chemical facts and processes are systematic, orderly, and generally clear and comprehensive. His theory was based upon the prevalent Aristotelian ideas. His published work upon mining and metallurgy possesses more permanent interest from a scientific point of view than the writing of Paracelsus because he confined himself to the task of presenting the established facts and processes of his specialty in clear detailed description, so that it might be of use for others who should follow in the same line of work. Many chemical facts and processes are mentioned that appear also in Paracelsus, but as with Paracelsus, so with Agricola there is no pretension that these are original with the author. It is interesting to note that neither one of these two men—the most important of their century in chemistry—seems to have been aware of the existence of the other. Agricola in Saxony and Paracelsus in Switzerland and

Austria possessed many interests and much knowledge in common, but Agricola's great work appeared after the death of Paracelsus, while those works of Paracelsus which contain most of his chemistry did not appear in print until after the death of Agricola. It is therefore not surprising that neither knew of the other. Agricola's great work *De re metallica* remains a classic in technical chemistry, while Paracelsus has left little that is of permanent interest to chemical science. But the reform of chemistry was not the main aim of the efforts of Paracelsus, to him that was but subordinate to his great ambition, the revolution of medicine.

Yet the influence of Paracelsus upon chemistry was epoch-making. By pointing out a rational and promising field for chemical activity and by his own successful application of chemically prepared remedies he inaugurated a movement which has continued without interruption and with increasing importance to the present day.

From his time on a new vitality was infused into chemical thought and activity. Instead of the passive acceptance of ancient authorities and traditions, there began a struggle for progress through experiments and their interpretation, often indeed unscientific and illogical at first, but nevertheless only from such beginnings of independent thought and initiative was the scientific spirit to be developed.

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